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THE DESROZIERS
DYNAMO-ELECTRIC MACHINE

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MULTIPOLAR MAGNETO ELECTRIC MACHINE

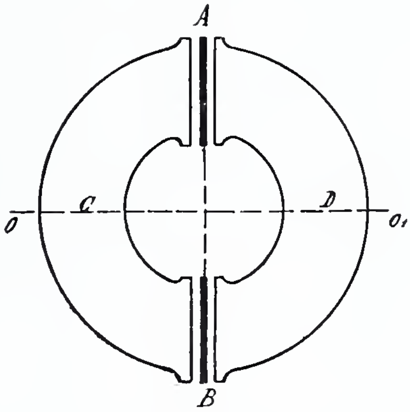
by M. E. DESROZIERS

Attempts have often been made to realise dynamo machines with non-magnetic induced part.

These machines are advantageously presented under the form of dises and their ideal type is Faraday's dise which gives, without commutation, an absolutely continuous current.

But, in practice what we understand by machines with non-magnetic induced part are dynamos formed of a thin armature AB *(fig. 1)* turning round an axis OO' and passing between an even number of poles of inductors such as CD regularly distributed round the armature.

Fig. 1.



These machines come under two categories : some give by commutation a current so slightly undulatory that they may be practically considered as machines with continuous current, the others are machines with alternating or redressed currents.

As a matter of fact these latter machines are the only ones which have been practically realised till now and numerous types of them can be cited such as the Siemens, Ferranti and other machines.

On every side the attempt to obtain an entirely practical realisation of the former has every-where failed in spite of the great interest which these machines present.

The cause of these repeated failures is due to the non observation of certain rules which a careful study has enabled us to evolve and which concern at one and the same time.

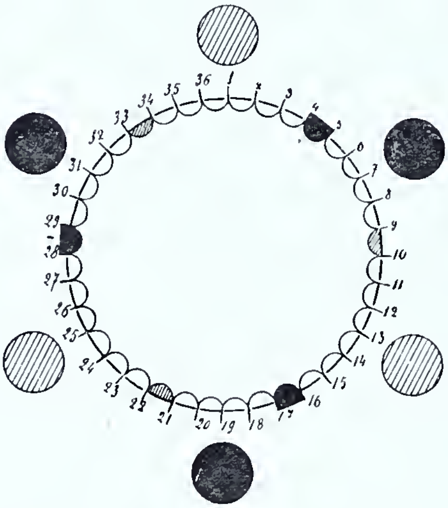
1° A manner of classing the induced elements which allows a simple systematic winding.

2° Forms of induced frames utilizing the greater part of the volume of the entrefer.

3° The manner of mechanically connecting the induced elements on the shaft or on the dragging plates.

In consequence of the circular movement of these machines just as for ordinary bipolar machines the different groups of induced frames which pass at the same time in the planes of commutation must be regularly arranged with regard to the radii or to the sides of regular convex *(fig. 2)* or starshaped polygons, *(fig. 3)* the number of the summits of which is in direct relation with the number of inductor poles.

Fig. 2.



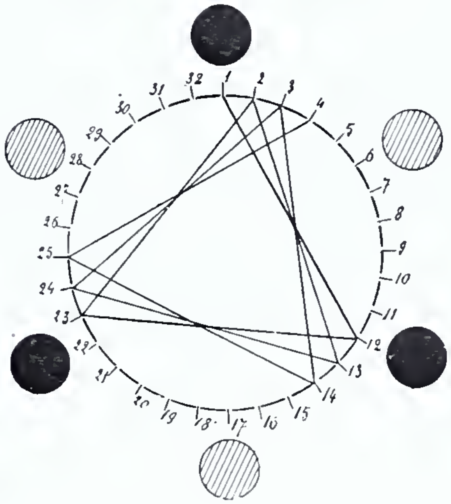
Figs. 2 and 3 have reference to cases of machines with six poles. The hatched circles represent schematically the zones of positive flux and the black circles the zones of negative flux.

Now from the point of view of construction and commutation, in *fig*. 2 there are really only six groups of induced frames the actions of which are separate, in spite of the high number of summits which is equal to 6×6, that is to say 36.

In *fig*. 3 on the contrary for only thirty-two summits there are sixteen groups the action of which are different.

The regular polygon-winding requires in fact symmetry according to the three axes of the figure both for groups such as 4-16 and 28 or 9-21-23 and for the inductor-fields. The result of this is an exaggerated number of induced groups and a series of drawbacks which show themselves both in the construction and the working.

Fig. 3.



The star-shaped-polygon-winding in which each induced group plays on the contrary a distinct part allows the number of these groups to be reduced to a minimum and the successive fields to be made independant.

In one word it is enough to realise the symmetry round a single axis just as in ordinary bipolar machines.

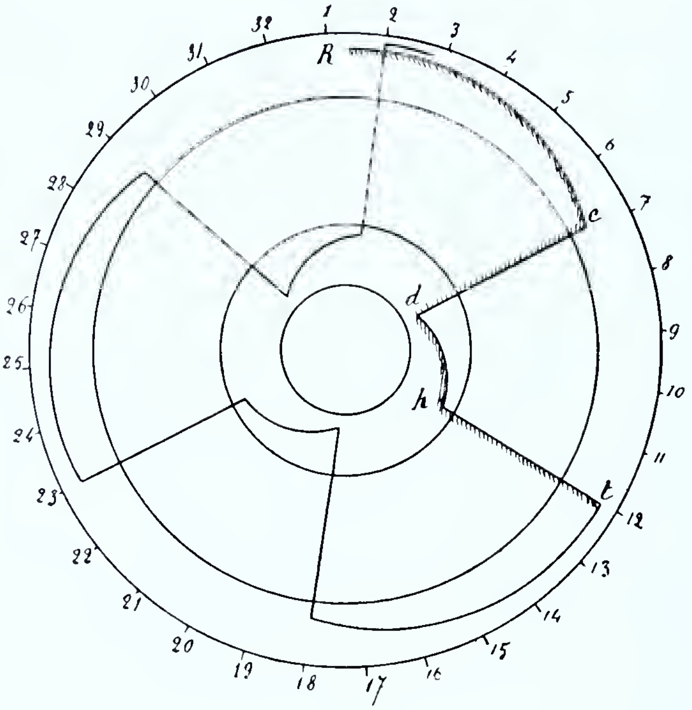
The star-shaped-polygon-winding symbolically represented by the sides of the polygon *(fig*. 3*)* seems it is true by the superposition of lines and by their entanglement to present a complication such as to frighten the practician.

This complication disappears if for instance instead of sides of a star-shaped-polygon the induced *tracing* be composed as in *fig*. 4, of elements R, *c*, *d*, *h*, *t*, formed of two *evolvents* and two radial parts, the number of summits contained between the radial parts being always an uneven number.

The elements starting from the uneven divisions of the circumference are all identical to each other. The same is the case with the elements starting from the even divisions.

The one and the other set can there fore be classed together and placed in series of elements suitably diricted in parallel planes on two distinct plates A*fc*, A'*c*' of *fig* 5 and 6. These figures represent the plates supposed parallel.

Fig. 4.



We can thus place in the same plane all the radial parts of one same series, some on the lower surface of the plate of *fig*. 5, the others on the upper surface of the plate of *fig*. 6, without these radial parts cutting each other at any point. All the *evolvents* of the same series are united parallel-wise on the upper surface of the plate of *fig*. 5 and on the lower surface of the plate of *fig*. 6.

It is sufficient then to unite the crowns face to face in such fashion that the radial parts are in juxtaposition in order to be able to make the ligatures at the circumference at the points *t*, so as to close the induced circuit thus constituted.

To facilitate this construction the crowns of the plates are pierced with holes for the reception of the joining pieces at the angles formed by the straight parts and the evolvents of one same element in R, *c*, *d*, *h*. In the same way the extremities R and *t* of one same element are suitably prolonged so as to facilitate the junction of one element to another.

To sum up, it has been sufficient to class the induced elements into two distinct series of identical parts and to form the induced frames exclusively of evolvents and straight parts. This method is susceptible of numerous variations based on the same principles. I will point out some of these.

Fig. 5.

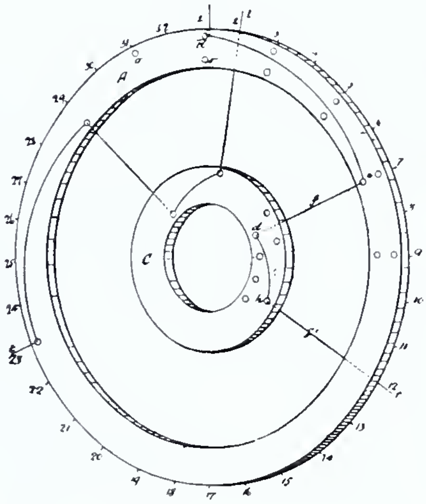
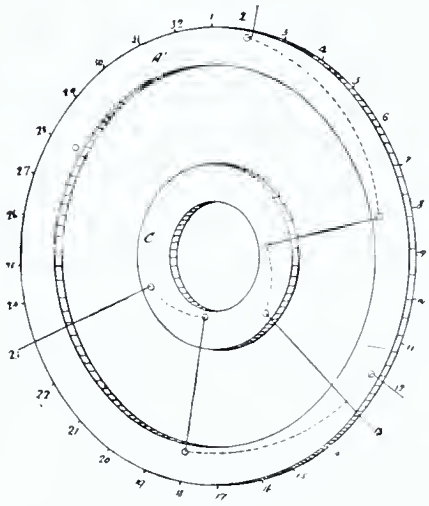


Fig. 6.



1° The induced element R, C, *d*, *h*, *t* (*fig.4*), can be divided into two parts at *d*.

All the parts such as *d*, *h*, *t*, on one hand and all the parts such as R, C, *d*, on the other are identical amongst themselves and can just as above be classed on two distinct plates.

2° The elements instead of having the complex form of an evolvent and a straight part can be made up either of one or several evolvents the somewhat complex form of which possesses the advantage of utilizing exactly the volume of entrefer or they may be made up in one or more straight lines which give rise to a simple construction.

The arrangement adopted in *fig*. 5 and 6 allows a disposition in loops united together (*fig*. 7 and 8) destined to multiply the induced effect of an element as in the ordinary multipliers and at the same time to insure a simple mechanical binding of the induced wire (*fig*. 9) to the shaft.

Fig. 7.

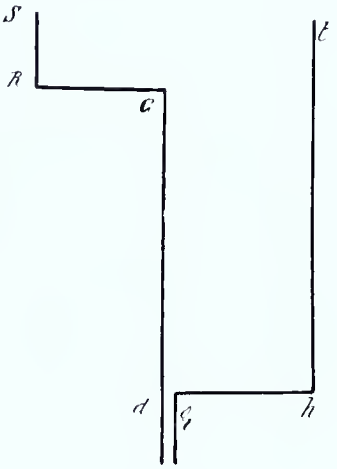
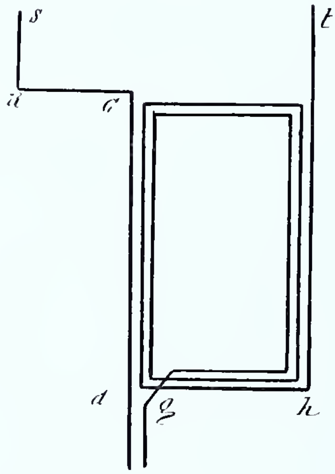


Fig. 8.



The joining pieces which unite the straight parts to the evolvents at R, C, *d*, *h*, are carried through the crowns A, C, in suitable holes and come to lean on them (*fig*. 9). We have now only to fix the crowns.

Between the crowns we intercalate a suitable metal star SS united to the axis OO' by a stock. On this star are fixed the crowns AC, A'C'. The induced is thus mechanically constituted. The accompany ing drawing represents a general view of this machine.

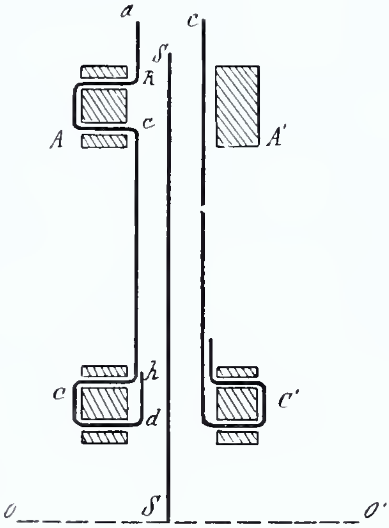
The connection of the induced elements to the collector is made in accordance with the following principles :

With the arrangements indicated above, the number of threads induced is of the form $2\ (n\ \mathrm{P}+1)\ m$, where n is half of the number of the fields, P a suitable paremeter allowing us to close the star shaped polygon and m the number of loops joined together in each element as above (*fig*. 8).

The number of the laminæ of the collector is of the form $(nP \pm 1)\, n$. These laminæ are distributed symmetrically with regard to the n axes of symmetry. The lamina at $\frac{360^\circ}{n}$ one from another are joined together in quantity by some arrangement and each of these groups of lamina is successively united in the natural order to one of the induced elements.

Two successive elements are thus intercalated between two successive laminæ.

Fig. 9.



It is sufficient to place two brushes at 180° to collect the current as in ordinary bipolar machines.

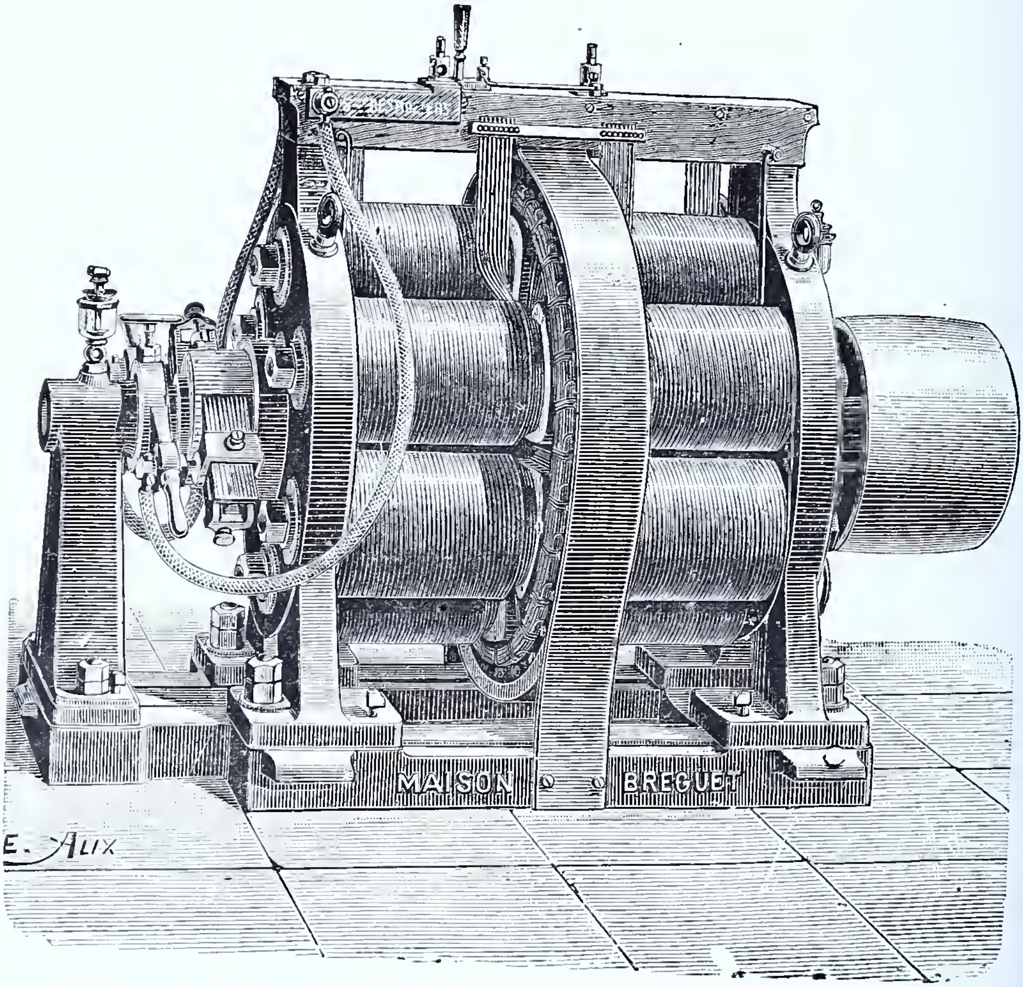
Under these conditions the brushes work irreproachably in big machines. For little machines where the variation of the flux is very rapid we have introduced a slight modification in the induced winding so as to avoid all sparking at the brushes.

This modification consists in a slight angular shifting of the radial induced bits such as *cd* and *ht (fig 4)* some in one direction, the others in another direction in such a manner that all the bits of one same group of elements should be able to pass together in the zones more or less narrow of change of direction of the flux where the variation of the magnetic flux is slow.

We can thus obtain a minimum variation of flux while the loops are being short-circuited under the brushes.

This correction gives rise to a geometrical disposition of the i duced elements analogous to that of the tracing of the balancing of the steps of a stair.

Fig. 10.



In the study of a project for a machine one naturally chooses the three parameters n, P and m, in order to get the practical figures most suitable for realizing the data of the problem. This, with the selection of the best proportions to give to machines is a study which necessitates both long calculations and continuous experimental study.

We can now give some interesting physical results.

Suppose

H to be the mean field C, G, S, of the induced zone, that is to say the quotient of the integral flux over the whole surface which the intuced part brushes.

V the mean speed of shifting,

I the intensity of the current of circulation in the induced elements.

The power ofagiven induced par t is proportional to the produce HVI. Let us examine the terms of this product.

1° V. The induced part is naturally light, its winding regularly and symmetrically dis posed does not alter, when at work, the state of equilibrium of the whole.

It is easy to give to these organs mean veloci ties of 20^{m} and 22^{m} per minute. We might go far beyond these results and arriveat velocities which would be double those of the machines most in vogue ;

2° H. The fields realized up till now have been high enough and go beyond the average values of 5000 and 6000 of flux (C, G, S) in the existing machines.

The machine presented to the Society has been able to work in our experiments with average values of 11.000 (C, G, S,)ofmagnetic flux.

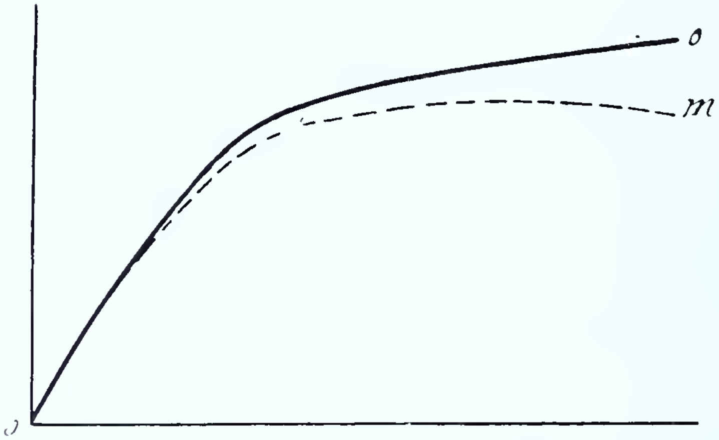
Our experiments lead us to believe that these high fields will be able to be used on machines of restricted dimensions for special purposes such as those used for the war Department and in the Navy.

It is certain, from our own experiments and our calculations that for powerful machines the want of which is felt in industrial circles we will be able to use these high fields. We have observed that whatever be the dimensions and the power of the machines the entrefer preserved a nearly constant value : consequent ly the magnetic circuit improves in proportion to the square of the dimensions.

We can conceive that in conditions of sufficient geometric development it should be possible to obtain high fields while devoting to this result only a slight outlay of inductor copper and a slight work of excitation.

It will be all the more easy to obtain these fields because the electrodynamic réaction of the armature on the inductors is very weak contrary to the results observed in other kinds of machines. Whilst in machines with magnetic armature the characteristic curve OO (*fig.* 11) with open circuit differs perceptibly from the characteristic curve with closed circuit and remains constant ly inferior to it by 15 and even by 20 por 100 the two characteristic curves in our machine are scarcely different by 1 to 2 por 100. They progress in a constantly ascendant movement a remarkable fact

Fig. 11.



which seems to have some analogy with the recent observations of professeur Ewing.

3° I. The value which the current can attain to per square millimeter of induced wire is one of the most important elements for consideration.

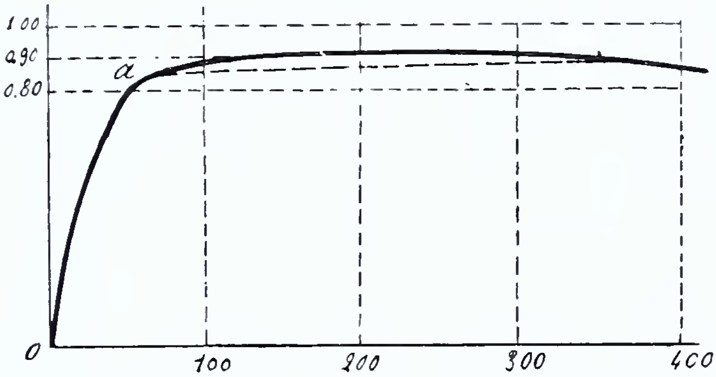
We have been able to make the induced wire bear as much as 15 ampères per square millimetre that is to say about three times the output of other machines.

This result is due to the fact that the Foucault's magnetic currents are done away with.

In other machines the force of the Foucault's currents resolves itself finally in heat which can scarcely dissipate itself otherwise than by the surface of the induced part...

In these machines then we must drain off both the heat of the Foucault's currents and the heat produced in the wires. Consequently for the skeleton of a machine with a given surface, undergoing a determined ventilation at a limited temperature it follows that we must reduce the output that this machine could give if it were not affected by the Foucault's currents.

Fig. 12.



This consideration is the more important because numerous experiments which have not been sufficiently dwelt upon show that the value of the energy of the Foucault's currents in existing machines is at least comparable to that of the heating of the induced wire according to Joule' law.

But this result is also due to the fact that the ventilation is naturally good. Each wire is sepa parated from its neighbour. The air in some way surrounds it on all sides.

In the movement of aspiration produced when in motion, this air carries off by convection the heat produced in each wire all the more easily because there is but litle parasitic supplementary heat.

One interesting consequence of the conjunction of these qualities is the following.

In consequence of the lightness of the induced part, of the suppression of the Foucault's magnetic currents, of the weakness of the reaction of the induced part on the inductors and the constant ascension of the characteristic curve, the net efficiency is little different from the electric efficiency and remains constant within very wide limits.

We find at most some differences of a few hundredths when we strain the output of the machine even beyond the limits of its normal working, as is seen (*fig.* 12).

In practice this is a fact of great importance for apparatuses do not work always at their maximum.

To sum up, the three factors V, H am I can easily and naturally attain high values.

At present certain machines realize one horse power net at their terminals per 20 kg of matter and in these 20 kg of matter the kilog of copper generates 350 watts. These results will certainly be surpassed by the powerful machines.

The studies and experiments for the construction of this machine were made in the workshops and with the collaboration of the maison Breguet.

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